Atomic Energy Control Board
P.O. Box 1046
Ottawa, Canada
K1P 5S9

Commission de contrôle de l'énergie atomique
C.P. 1046
Ottawa, Canada
K1P 5S9

INFO-0207

SOME THOUGHTS ABOUT RISK

by

J.H. Jennekens

Atomic Energy Control Board
Ottawa, Canada

May 1986

Canada

Paper

SOME THOUGHTS ABOUT RISK

A paper presented at the "Symposium on the Total Risk and Benefit Impact of Energy Alternatives", University of Waterloo, May 20-23, 1986.

ABSTRACT

The author discusses how the concept of risk is perceived differently by the scientist and the man in the street, and mentions the problems that this can sometimes pose for the regulator. He also gives examples of inconsistencies and contradictions in various areas of risk management. He concludes by noting that so-called accidents usually do not occur by chance, but that system or component failures are always due to some form of human error. The objective of risk management is to ensure, by a process of rigorous analysis, that both the probability and consequences of such failures are minimized.

RÉSUMÉ

L'auteur traite des problèmes auxquels tout organisme de réglementation doit parfois faire face à cause de la conception différente que les scientifiques et le public en général ont du risque. Il fournit aussi des exemples d'incohérence et de contradiction dans plusieurs domaines de la gestion du risque. Il conclut en notant que les prétendus accidents ne sont pas normalement attribuables au hasard, mais plutôt que les défaillances de systèmes ou de composants dépendent toujours d'une forme quelconque d'erreur humaine. La gestion du risque vise d'abord et avant tout à assurer, grâce à un processus d'analyse rigoureux, que la probabilité et les conséquences de telles défaillances soient minimisées.

SOME THOUGHTS ABOUT RISK

I. INTRODUCTION

On looking back at the difficult days of the Cold War, British Prime Minister Harold MacMillan remarked:

"To be alive at all involves some risks"

During the past three days, a number of excellent scientific and technical papers have been presented on various aspects of risk. More than one-third of these papers were presented by members of the national and international academic communities. Similarly, one-half of the papers to be presented tomorrow were prepared by academics. In terms of quality, relevance and utility the papers already presented by academics were exemplary, and I fully expect that the remaining papers will be equally so.

I mention these points in the context of a statement that appears in a report to the Ministerial Task Force on Program Review (better known as the "Nielsen Task Force") by one of two study teams, namely:

> "..... the Study Team believes that a strong case can be made to expand the number of full-time members of the AECB. Moreover, an expansion in the number of full-time members could provide an opportunity for broadening the representation on the Board (some criticism was expressed in our consultation process on the preponderance of academics on the Board). Accordingly, we agree with the view of the Study Team on Regulatory Programs that the Minister of Energy, Mines and Resources should review the structure of the AECB and expand the number of members to include more permanent members representing industry, labour and public interests. The Study Team also suggests that such a review address whether there would be a need in an expanded Board to retain any part-time members."

In view of past allegations of conflict of interest, it is not obvious how representatives from industry, labour and public interest groups could be appointed to the Board, but more importantly, a proscription against academics would be absurd. From its founding in 1946, the AECB has operated with one full-time member and up to four part-time members, one of whom is an ex-officio member by virtue of his appointment as president of the National Research Council. The three current part-time members of the Board can be described as academics, although all three have senior executive level with administrative and research responsibilities.

Acceptance by the Government of the Study Team's recommendations would involve certain risks, albeit low probability but obviously high consequence risks. The current and past part-time members of the Board have made outstanding contributions to the public interest, contributions that have been characterized by consistently high standards of quality, relevance and utility. I would much prefer to see a continuation of the alleged excess influence of academics than a switch to some of the self-appointed spokesmen for the public interest, whose cynical criticisms of regulators and industry alike are no more valid than their guarantees of future catastrophes.

Since 1956, the Atomic Energy Control Board has relied heavily on advisory committees consisting of independent experts drawn from the scientific disciplines. In 1979, the Board restructured its advisory committee system and created two senior level scientific committees, known as the Advisory Committee on Radiological Protection and the Advisory Committee on Nuclear Safety. These committees are concerned with principles, basic criteria, standards, and general practices.

In its June 1981 report to the Board, the Advisory Committee on Nuclear Safety listed four general objectives, which it believed should underlie the regulation of nuclear activities in Canada. These objectives are:

"1) nuclear activities should not lead to unacceptable risks to the workers involved or to the general public;

2) for hazards due to ionizing radiation,

   (a) all early detrimental effects on individuals should be avoided and the risks of deferred effects should be minimized;

   (b) the probability of possible malfunctions which could lead to the escape of radioactive material or the exposure of people to ionizing radiation should be limited to small values decreasing as the severity of the potential consequences increases so that the likelihood of catastrophic accidents is virtually zero;

3) for non-radiological risks,

   (a) the risk to workers and members of the public should be equal to or less than that posed by comparable industries or activities;

   (b) the probability and potential consequences of possible malfunctions which could lead to harm of workers or members of the public should be as low as practicable; and

4) the risk to any future generation associated with each nuclear activity should be taken into account and given a priority for prevention not less than that given to risks presented to the current generation."

In light of the April 26, 1986 tragedy at Unit #4 of the Chernobyl nuclear power station in the USSR, it is evident that the unquestionably valid safety objectives recommended by the Board's advisory committee, and subsequently endorsed by the Board, were not achieved by the Soviet authorities in at least one instance.

Recognizing that its June 1981 recommendations were expressed in very broad, qualitative terms, the Advisory Committee on Nuclear Safety undertook the preparation of a more detailed set of recommendations on safety requirements for nuclear power stations. These requirements embrace all of the aspects of interest, including dose limits, siting, design, safety analysis, construction, commissioning, operation, effluent and waste management, and decommissioning. With respect to safety analysis, the Committee reaffirmed the importance of retaining certain long-established deterministic design

requirements to ensure defence-in-depth against potential incidents. The Committee further recommended:

> "the judicious use of probability arguments in which values of system unavailability or failure frequency must be based upon direct experience or reasonable extrapolations therefrom".

The wisdom of the Committee and of the longstanding Canadian practice of imposing certain very rigorous deterministic requirements, regardless of ostensibly reasonable probabilities to the contrary, has been dramatically reinforced by the Chernobyl tragedy. In the words of Confucius:

> "The cautious seldom err, for caution is the eldest child of wisdom".

II. THE CONCEPT OF RISK - SOME CONTRADICTIONS

The concept of risk means different things to different people. To the scientist, the risk of an activity is usually considered to be some mathematical function of the possible harm that the activity could cause, and the likelihood that such harm will be caused by the activity. For example, if a jumbo jet flies from Toronto to Vancouver with 350 people on board, the possible harm is the death of the 350 people in a crash, and certainly many more if the crash occurred in a populated area, and the direct and indirect adverse effects on their families and friends. The scientist, on the basis of experience, can calculate the probability of the plane crashing. The risk, to him, is a function of that probability, the death of many persons, and the totality of subsequent effects.

Not surprisingly, studies have shown that the concept of risk as understood by the man in the street may not be the same as that of the scientist. In one study, a group of people were asked to rank 30 activities on the basis of the number of deaths that they would expect the activities to cause, on average. Nuclear power was rated as likely to cause a smaller number of deaths than most of the others. But when these same persons were asked to rate the identical activities on the basis of which they thought were more dangerous, they rated nuclear power as the most dangerous.

We often read reports in the media about the detection of poisonous substances in water bodies, with the implication that any amount of a dangerous material, no matter how small, constitutes an unacceptable risk. The extension of this implication is that as we become more and more clever at detecting smaller and smaller concentrations of contaminants, we must make our water more and more pure to avoid this perceived risk.

So it is quite apparent that to the scientist, to the journalist, and to the man on the street, the concept of risk can mean quite different things.

To a government regulator such as the AECB, these different conceptions of risk can pose certain problems. Our regulatory staff are generally people trained in the scientific method, and therefore they want to deal with risk in a logical and scientific way. On the other hand, our salaries are paid from taxpayers' dollars, and we are expected to do our jobs in such a way as to reflect the wishes of the public as far as we can determine them. Our immediate masters are politicians who are very sensitive to what the media are

saying. When our scientific training tells us to do one thing, and the desires of the public or politicians tell us to do something else, we are faced with a difficult dilemma. The only practical way out of this dilemma is to try as well as we can to pursue the scientific approach within the constraints of the public and political pressures that we face.

If we step back and look at the broad picture of risk management in general, we see many things that are inconsistent or even contradictory. I would like to mention a few examples of these contradictory things, to give you some food for thought during the discussions on risk management in the remaining technical sessions of this Symposium.

The AECB is responsible for licensing many types of facilities, including nuclear reactors and heavy water plants. Both contain large inventories of substances which would be dangerous to the public if they were released in appreciable quantities. Reactors have radioactive products resulting from the fissioning of uranium and plutonium, while heavy water plants have large quantities of the poisonous gas hydrogen sulphide.

For nuclear power stations, the AECB sets safety standards that have evolved over a period of almost four decades. These have resulted from a number of inputs, including our own experience with research and power reactors, an awareness of international practice, and our perception that the public considers serious failures at nuclear reactors to be more undesirable than equally serious failures at other types of industrial plants. Whenever we propose to make changes to our safety requirements, any change that is perceived by the public as being a relaxation of a safety standard has been vehemently opposed. Recognizing that certain persons hold contrary views, we believe that our nuclear safety standards are second to none in terms of international practice and generally in accordance with public expectations.

On the other hand, heavy water production plants are essentially chemical plants that contain poisonous gases but no radioactive material. Our licensees have argued that it would be inconsistent to require such plants to meet safety standards significantly different from those applied to other chemical or industrial plants which utilize hydrogen sulphide or other hazardous chemicals. With certain important exceptions, the safety standards that we set for heavy water plants are generally consistent with safety standards for similar plants in the chemical industry.

The net result is that we require that both nuclear reactors and heavy water plants be designed and operated to high standards of safety. However, there is no question that the standards of safety required for nuclear reactors and heavy water production plants are higher than those required for chemical plants. There is obviously a contradiction here, and although some persons may believe that we are being inconsistent, we believe this to be the best approach.

Another interesting contradiction arises when we consider medical x-rays. The AECB has come in for its share of criticism from certain members of the medical community. I might mention in particular the British Columbia Medical Association, which has declared the AECB "Unfit to Regulate" and called for replacement of the AECB by, and I quote, "a more independent regulatory agency". The BCMA makes this assertion in a document erroneously referred to

as a "study". The document is hardly a scholarly work; in fact it is an insult to the medical profession. However, the BCMA report is another story, and although I believe that future historians will cite it as one of the clearest examples of hypocrisy, I must return to the subject at hand.

The AECB's Advisory Committee on Radiological Protection recently conducted a study of radiation doses received by Canadians from medical diagnostic procedures using x-rays. The preliminary conclusion of this study is that, on average, Canadians receive a radiation dose of 2 millisieverts per year (200 millirem per year) from medical x-rays. This is many times larger than the dose that any member of the public receives from activities that are regulated by the AECB, even members of the public living in the vicinity of nuclear reactors. I have no reason to expect that British Columbia is different from the rest of the country, and it seems paradoxical to me that a group which criticizes the fitness of the AECB to regulate radiation doses is itself a major contributor to what is by far the largest source of man-made radiation to which Canadians are exposed. Although there are encouraging indications of a recognition by the medical profession of the need to address this matter, it is evident that substantive action will be required.

There can be no doubt that decisions regarding the potential risks and benefits of diagnostic x-rays are decisions that the physician must make, and I would not want to suggest that they should be anybody else's decisions. But I would like to mention a few important considerations.

Firstly, in regulating the nuclear power industry we insist on a principle called ALARA, an abbreviation that stands for "As Low as Reasonably Achievable". This means that even if a dose of radiation is acceptably small, if it can be reasonably avoided then it must be avoided. The medical profession has no corresponding principle that would minimize the radiation exposure to people from diagnostic x-rays. In fact, it is common for physicians to order multiple x-rays of a part of the body from various angles, rather than to minimize the number of exposures and after examining the results ordering more if necessary. The pressures that we as a society impose on the medical profession are such that physicians tend to specify more rather than fewer x-rays to avoid the possibility of being sued for missing something. Thus, the net result is that while the ALARA principle is applied to the nuclear industry and other activities licensed by the AECB, it is not applied to radiation doses from medical x-rays.

Secondly, a great deal is said these days about low level radiation, and several self-appointed "watchdogs" claim that not enough is known about the hazards of low level radiation. If the claims of these persons were true, if the low amounts of radiation exposure of the public due to the many agricultural, industrial and clinical uses of radioisotopes and nuclear energy were a significant hazard to the public, then it would logically follow that the much larger exposures from medical X-rays would constitute a much greater health hazard.

We find another interesting contradiction when we look at the nature of the opposition to certain nuclear activities - nuclear power reactors, uranium mines, and nuclear research facilities. The people most at risk from these activities are of course the people who work in the facilities themselves - the reactor operators, the miners and the researchers. They are closely

followed in the risk stakes by the people who live in the vicinity, who generally include the families of the workers as well. But what we find is that the people who oppose such activities are often not the people who are at risk, but people who live far away from the potential hazard. When there was a furor a few years ago about the safety of the NPD generating station at Rolphton, it was the local residents - the very people whose children's health would be jeopardized if there were a serious failure - who were most outspoken in defending the plant, while politicians and others from Toronto and Ottawa were condemning it as unsafe.

To some extent this is because the people who work and live around the plants are more knowledgeable about its safety. It is also recognized that people are prepared to accept some risk to protect their jobs or the local economy. While at first sight this may seem crass, one of the health risks that is not often recognized in our society is the health risk of unemployment.

III. CONCLUSION

Well what does all of this mean, and what lessons, if any, can be learned from these considerations? Most certainly there are many other contradictions and inconsistencies in our daily lives, the nuclear field holds no monopoly over logical incongruities. Although I remember very distinctly the long and vituperative arguments that took place with members of organized labour who fought so strenuously, justifiably and successfully 15 years ago to bring about improvements in the working conditions in uranium and other mines in Ontario, I wonder whether at least some of their energies should have been directed elsewhere. As we faced each other in smoke-filled meeting rooms, many of the participants rubbed their yellowish-brown, stained fingers as they grew numb from writing notes to their leaders, determined to ensure that no argument suffered from the lack of factual examples. In the armed forces, self-inflicted wounds are classified as punishable offences. Perhaps the bronchial epithelia of uranium mine workers should be protected from the traumatic insult of tobacco smoke as the first and most important step in improving their health and longevity.

To answer my own question, I am tempted to suggest that what these various things mean is that all of us who in one way or another are involved in some aspect of public and occupational risk must not rest on our past accomplishments. In this address, I have purposely avoided the use of the word "accident", simply because I believe it to be an inexcusable euphemism, a term mistakenly used to mean a chance occurrence. On many occasions, certain members of the media and persons claiming to be knowledgeable critics allege that those of us who are involved in some aspect of the nuclear field fear to use the word accident, preferring instead to speak of events or incidents. It is not that we fear the use of the word accident, it is because we abhor the term. When a component or a system fails in any man-made apparatus, the failure did not occur by chance. Such failures are due to design oversights, manufacturing defects or operating error - all are attributable to human error of one form or another. When the initiating event and subsequent series of events are known about the Chernobyl tragedy, it will likely be abundantly clear that whether it was a failure of electrical supply to the primary and secondary coolant pumps; an

unanticipated release of "Wigner" energy in the graphite moderator; a localized perturbation in neutron flux, which led to a rapid escalation of fuel failures; the brittle fracture of a coolant assembly followed by instantaneous propagation of the failure, involving many pressure tubes and a subsequent graphite-water or metal-water explosion; or some unsuspected interruption in primary coolant flow, which eventually resulted in an uncoolable geometry of the fuel, that whatever the cause, it did not happen by chance. Ignorance, (e.g. lack of scientific knowledge and understanding, or the more vulgar meaning of the term,) carelessness, avoidable and not unexpected causes, and all of the other so-called accident factors quite obviously do not occur "by chance". The challenge that faces each of us in our respective endeavours is to minimize the probability of systematic and random failures, and to ensure by a process of rigorous analysis involving deterministically stipulated major failures that the probability of postulated events or incidents is minimized, and that the consequences of inevitable failures, none of which are "accidental", will also be minimized.